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JPRS L/8276

13 February 1979

EAST

EUROPE

TRANSLATIONS ON EASTERN EUROPE

SCIENTIFIC AFFAIRS

(FOUO 1/79)

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(FOUO 1/79)

CONTENTS PAGE

CZECHOSLOVAKIA

RESEARCH CENTER PLANS TO PRODUCE NUCLEAR REACTORS

Bratislava NOVE SLOVO in Slovak No 44, 2 Nov 78 p 5

[Article by Peter Pribyl: "Our Atomic Town--The Activity of the Nuclear Research Institute in Rez"]

[Text] Since 1957 when the first Czechoslovak nuclear reactor was put into operation in Rez near Prague that "atomic town" has become well known both in our country and abroad. It is true that since that time the nuclear research base has spread and our first atomic power plant was built in Jaslovske Bohunice, soon to be followed by V-1 and V-2 nuclear plants. Rez, or rather the Nuclear Research Institute located in Rez, ceased to have a monopoly on nuclear science in Czechoslovakia. Nevertheless, it is still the largest research center for nuclear reactions and a source of incentives in this field of science which has not been sufficiently explored.

Safety Above All

According to the conclusions of the CEMA Permanent Commission for Atomic Energy and according to the program for cooperation of the CEMA member states in the field of nuclear power, in 1981-1984 Czechoslovakia plans to produce 10 complete reactors for the USSR and 8 for our domestic use. The reactors will be of the VVER-440 type, while higher-capacity reactors (VVER-1000) will be manufactured in the USSR. From reports in our press on the Czechoslovak nuclear program, we are informed how the preparations for the production of components for nuclear reactors have progressed in the Skoda Works in Plzen, in Vitkovice, etc. Although their production is based on Soviet designs, gradual improvements and innovations will be introduced (they are already being introduced now--in the stage of their ongoing development) by Czechoslovak technicians and workmen from the manufacturing enterprises and from nuclear research centers. A "firsthand" impact of the nuclear program is thus felt in Rez.

We expect that in the future, after 1985, the VVER-1000 reactors will also be produced in our country, so to say, after some experience with them in the USSR. However, even before that, the experts in Rez will deal with the solution of more urgent and vital problems.

Among them is the problem of protecting the environments of nuclear power plants against accidental breakdown of the reactor. Reactors operating in the world are protected by such safety features that in the estimate of experts the probability of a breakdown is in fact extremely remote; with 1,000 reactors in operation in the world, only one of them would break down in 100 years...Even then, however, the contamination which would spread from it would have extremely pernicious and tragic consequences. Therefore, nuclear research workers everywhere in the world are working on methods for prevention of contamination in case of a real breakdown. In the West such a solution has been found in so-called "full-pressure containment." Soviet experts developed the so-called "bubbling cycle," which includes, among other things, an enclosure of the primary and secondary systems of the reactor in reinforced concrete casing. Our researchers developed the system of the so-called "double container" around the reactor in which the fission takes place. It is basically an inner steel packing built around the area of the reaction, which is wrapped in an outer container made of reinforced concrete, with filters between both cycles, with monitored sealing of both containers, etc. The CSSR offered this solution to the Soviet Union because nuclear power plants are being built there as well as in our country in areas with relatively high density of population, and according to the calculations by our experts, the double container method provides an efficient protection against contamination in such conditions.

Growing Pains

It is a fact that Czechoslovak industry did not have to start from zero in the implementation of its nuclear program. However, when compared with the challenges of the traditional steam or water power engineering, the challenges of nuclear engineering are so demanding that they may cause problems during the transition to new technologies. For instance, it is absolutely necessary to rebuild the steel works and to develop completely new types of special steel for the construction of even more advanced model 440 reactors. In that connection the Nuclear Research Institute in Rez has participated in developing steel for the pressure container of the reactor (it is undergoing tests this year).

Although the Nuclear Research Institute has been operating for more than 20 years, it is just beginning, if we consider that the whole nuclear age is still before us. No wonder that in its research work the institute is still encountering problems which may be regarded as its "childhood diseases." However, if such diseases are not "treated" properly and become chronic and protracted, they might turn into serious afflictions in maturity. The institute is struggling because of a lack of technical equipment to be delivered by the Machinery and Automation Plants, Tesla and other enterprises.

Naturally, for its highly specialized work it needs highly specialized instruments which must be individually crafted or manufactured in limited lots. The manufacturing enterprises, however, are interested in large quantities because they make it easier for them to meet their plans. At present the Tesla national enterprise in Vrable has designated one of its plants for the manufacture of instruments for nuclear research and the Machinery and Automation Plants is planning the construction of new capacities, among other things, also for the above-mentioned type of equipment.

Moreover, it is encouraging that a new research-production organization for the manufacture of model and limited-lot equipment for nuclear research will be built in Slovakia; it will be managed by the Czechoslovak Commission for Atomic Energy. About 150 employees will work in that center for which space has been provided in Spisska Nova Ves.

Unrestricted Cooperation

The Nuclear Research Institute in Rez near Prague has been closely cooperating for a long time with similar institutes in other CEMA countries.

It has cooperated most closely and for the longest time with Soviet institutions. That is the basis for most of the activities in the Nuclear Research Institute. The Institute takes part in supplying--developing, planning, innovating, testing, retesting, calculating, etc--Czechoslovak equipment for the Soviet nuclear program. Thus, for example, it participated in the deliveries of steam generators for the atomic power plants in the town of Shevchenko in the Ukraine.

When completed, additional power plants which will be built in that Soviet republic with the aid of other CEMA countries will supply those countries with power. The CSSR is interested in that construction as well as in the purchase of power; pertinent negotiations and considerations are therefore reflected in the activities of the institute in Rez.

Contacts with capitalist partners are taking place within the International Agency for Atomic Energy of which the already mentioned Czechoslovak Commission for Atomic Energy is a member. For instance, our neighbor, Austria, has problems similar to ours (a lack of other kinds of energy) and also intends to concentrate more intensively on nuclear energy; it is building a nuclear power plant in Tulln on the Danube. Discussions on joint air-pollution control, particularly in the border areas, water control, etc, are under way.

Only Reactors Are Involved

The Nuclear Research Institute is a place for explicitly applied research. Its achievements affect increasingly more economic sectors and departments. Activities or processes developed in Rez have gained for our national economy annual profits or savings amounting to tens of millions of Kcs, and that amount is still growing.

For instance, while adopting the process of nuclear reaction, a technological method for reprocessing of deteriorated nuclear fuel was developed; it is based on the use of gaseous fluorine and hydrogen fluoride. Moreover, several "nonnuclear" applications were discovered during that process, among them a facility for cleaning synthetic diamonds. This method has already been applied in the Pramet national enterprise in Sumperk. The number of technological processes applying from the very beginning of the development of nuclear technology for nonnuclear purposes is constantly growing.

Agriculture: The so-called Dewar's flask used for insemination of cattle are now produced by the machine-tractor station in Ricany.

Food industry: The Nuclear Research Institute irradiated scores of quintals of potatoes and onions for the Research Institute of Agricultural Technology in Prague and for the Research Institute of Food Industry in Bratislava to prevent the vegetables from sprouting and thus, to prolong their storage. Mushrooms were irradiated from the Mycological Institute in Prague. The radiation did not affect the taste of these foods and substantially prolonged the period during which they stayed fresh.

Medicine: Radiopharmaceutical drugs are produced in Rez. Since 1974, the 131-J agent (containing iodine) has been distributed in hospitals all over Czechoslovakia. This agent has replaced painful examination processes and facilitates more precise diagnosis. The presence of the 131-J radioisotope helps observe the conditions and function of this or that organ in the human body (kidney, liver, etc).

Conservation and restoration of cultural treasures: The so-called bionegative effects of radiation are becoming increasingly more useful in extermination of ligniperdous insects in valuable wooden artifacts in museums, churches, etc. In its large-capacity radiation source the institute has treated painted panels, wooden statues and other valuable objects of immense financial and artistic value which would be otherwise destroyed by the "ravages of time." In its approach to cultural treasures the institute has found a particularly resourceful partner in the Central Bohemia Museum in Roztoky near Prague which has built its own radiation chamber with a cobalt emitter for the treatment of precious collections.

Naturally, the application of methods developed in Rez is not spreading uniformly in every field and department. It has found relatively very rapid application in medicine and the rubber industry as well as in the manufacture of cables, while its progress in the chemical industry has been relatively slow. This is somewhat startling, since next to mechanical and power engineering, chemistry is exactly the field from which we shall demand increasingly larger quantities and higher quality of products, and that cannot be accomplished without modern technology.

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CONCRETE STRUCTURES UNDER MISSILE IMPACT LOADING

Prague JADERNA ENERGIE in English No 10, 1978 pp 362-368

[Article by Vladislav Adamik, Power Research Institute, Jaslovske' Bohunice]

[Text] *A theoretical computational approach to allow prediction of damage in reinforced concrete walls under axisymmetric missile impacts is outlined. Special routines defining the concrete behaviour during the impact have been integrated in the two-dimensional Lagrangian code CEFRA and the calculation of the impacts for nondeformable missiles has been performed. The results reveal that the theoretical model is credible and makes possible to treat with the appropriate accuracy the other similar problems of extreme containment loads within the whole range which is needed for the reactor safety programme.*

1. INTRODUCTION

Nuclear power plants are commonly protected by reinforced concrete structures. Improved building design to resist impact damage, from possible missiles or explosions, requires quantitative predictions of damage in the reinforced concrete from postulated missiles, in the velocity ranges of interest. The existing results about impact loadings consist of empirical penetration equations, derived from high velocity data gathered for ordnance applications. Such information has limited value when extrapolated outside the experimental bounds, as it is needed for the reactor safety programme.

The scope of this paper is the theoretical study of the reinforced concrete structures behaviour under missile impact loading. The local deformations in all directions, the plasticity, all the failures and the stress waves at surroundings of the impact zone are taken into consideration. As, it is supposed that the impacting time is short in comparison to the inverse of the fundamental eigenfrequency of the structure, the impacted zone with its surroundings have been isolated from the total structure.

Special routines defining the concrete behaviour during the impact have been developed and integrated in the two-dimensional Lagrangian code CEFRA

[1] and the calculations of the impacts for nondeformable missiles have been done and the results compared with the experiment.

2. THE THEORETICAL MODEL OF CONCRETE

The material model for the concrete which is subjected to the high energy impact must include not only elastic and plastic region but also all real types of concrete failure modes. The model presented here assumes that the deformations and stresses of the concrete can be always expressed by a hydrostatic and deviator components with the assumption of isotropic behaviour of the concrete.

Linear region. Linear elastic constitutive equations are:

$$J_1 = 3KI_1$$

$$s_i = 2\mu e_i; \quad i = 1, 2, 3. \qquad (1)$$

Elastic surface h for concrete derived by Ottosen [2] is used:

$$h = J_1^2/(2.0 . \sigma_c)^2 + S_2/(0.236 . \sigma_c)^2 - 1 . \qquad (2)$$

If $h \leq 0$ then the stresses are in the elastic range (but there is some restriction when tensile stresses occur, see failure due to tensile stresses) and if $h > 0$ plasticity will occur.

Plastic region. For stresses beyond the elastic limit, the von Mises yield criterion is employed:

$$S_2 - 1/3\sigma_0^2 = 0 \qquad (3)$$

where σ_0 is a function of the hydrostatic pressure p (Mohr-Coulomb yield model is used).

Modes of failure. Generally three types of the concrete failure must be taken into consideration:

a) cracking — failure caused by tensile stresses after which the gaps generated are not filled with fracture segments,

b) failure due to shear deformation — the failure caused by shear deformation after which gaps are immediately filled with fracture segments and the failured concrete behaves like dry sand,

c) crushing — the failure due to the grains reordening, caused by the high hydrostatic pressure and by the porosity of the concrete; effects of this failure are the same as in the failure mode b).

The failure modes are determined by using the failure surface of Ottosen [2], see fig. 1:

$$A \cdot S_2/\sigma_c^2 + \lambda S_2^{1/2}/\sigma_c + BJ_1/\sigma_c - 1 = 0 \qquad (4)$$

where

$$\lambda = K_1 \cos\{1/3 \operatorname{Arcos}(K_2 \cos 3\Theta)\} \ \ldots \ \cos 3\Theta \geq 0$$

$$\lambda = K_1 \cos\{\pi/3 - 1/3 \operatorname{Arcos}(-K_2 \cos 3\Theta)\} \ \ldots \ \cos 3\Theta < 0 .$$

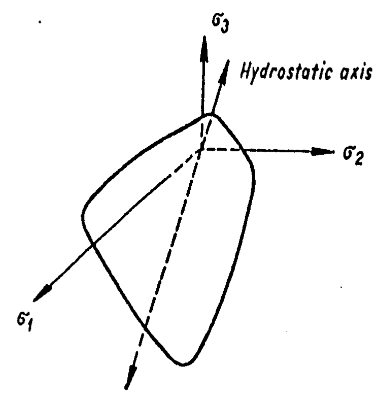

Fig. 1. The principal appearance of the concrete failure surface (axonometric projection). From [2]

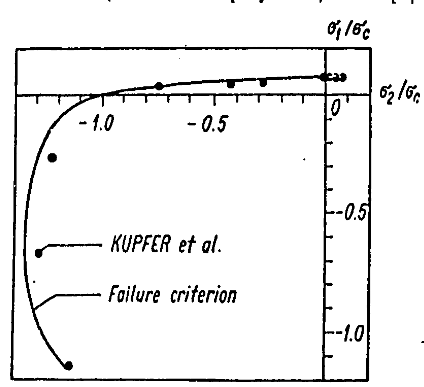

Fig. 2. Comparison between the failure criterion ($k = 0.08$) and the tests of Kupfer et al. (σ_c = 50.4 MN/m²). Biaxial stress state. From [2]

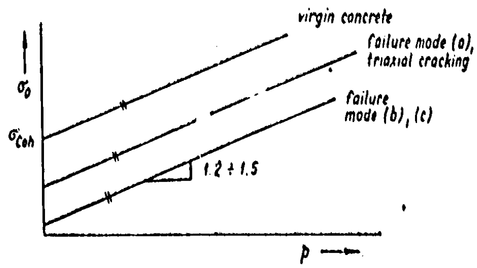

Fig. 3. Yield function for virgin and for failured concrete

The main characteristics of this failure surface are following:

— The four parameters A, B, K_1, K_2 are used and are determined so that the experimental values σ_c, σ_t, σ_b and the experimental stess state on compressive meridian are contained in the criterion.

— It involves only invariants, i.e. it is unnecessary to arrange the stresses in the smallest, intermediate, and greatest stress order.

— It is valid for all stress combinations, and it gives a reliable estimate to the experimental tests of Kupfer et al. [3], see fig. 2. Any state of stress which is on the surface represents a failure. The stress vector cannot lie outside the surface.

— The values of the four parameters A, B, K_1, K_2 are dependent on the value of parameter k.

Yield limit models. After the failure modes b) and c) and after the triaxial cracking the concrete is treated as a granular material which has the yield limit linearly dependent on the hydrostatic pressure. The yield functions used for virgin and failed concrete are shown in fig. 3.

Failure scheme. The most important part of the theoretical model is the description of the concrete history during the impact from the original state up to failed concrete. For this purpose, the following failure scheme has been developed, see fig. 4.

First, the principal stresses are established and the failure criterion of Ottosen is check up. Failure leads to a crack which is perpendicular to σ_i if σ_i is a tensile stress or to a generalized microcracking (crushing) of all principal stresses are negative. As it may be seen from the fig. 4, failure scheme results in four final material states: „sand" material 1, 2, 3, 4 and in the two types of partial cracking. In the later case

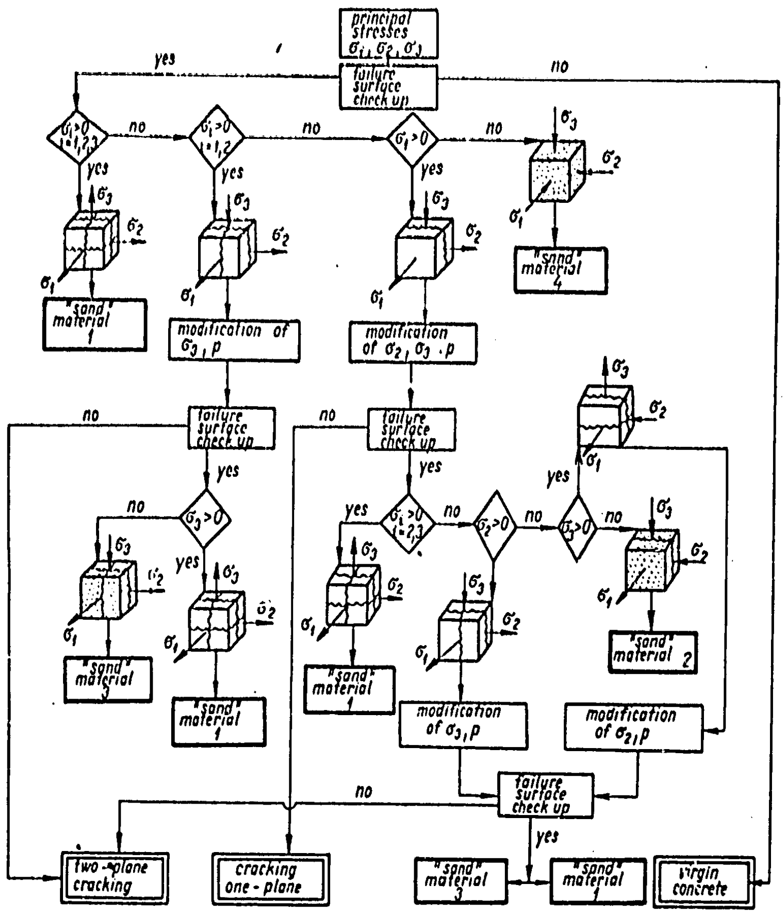

Fig. 4. Failure scheme of concrete cracking and crushing

the further history of cracks is treated by the approach from the code TENSOR [4] until one of the possible final material types is reached.

The method for the cracks treating is based on the assumption that the material in the vicinity of the cracks can be described by the linear stress-strain theory. After one-plane crack (for example $\sigma_1 > 0$) the principal stresses must be corrected and also there is a change of E_1 (initially $E_i = 0$; $i = 1, 2, 3$):

$$
\begin{aligned}
\sigma_1' &= 0 \\
\sigma_2' &= \sigma_2 + \lambda \Delta E_1 \\
\sigma_3' &= \sigma_3 + \lambda \Delta E_1 \\
\Delta E_1 &= -\sigma_1/(\lambda + 2\mu) \\
p &= -1/3(\sigma_1' + \sigma_2' + \sigma_3') .
\end{aligned}
\tag{5}
$$

After two-plane cracks ($\sigma_1 > 0, \sigma_2 > 0$) we have:

$$\begin{aligned} \sigma_1' &= 0 \\ \sigma_2' &= 0 \\ \sigma_3' &= \sigma_3 + \lambda(\Delta E_1 + \Delta E_2) \\ \Delta E_1 &= [\lambda\sigma_2 - (\lambda + 2\mu)\,\sigma_1]/[2\mu(2\lambda + 2\mu)] \\ \Delta E_2 &= [\lambda\sigma_1 - (\lambda + 2\mu)\,\sigma_2]/[2\mu(2\lambda + 2\mu)] \\ p &= -1/3(\sigma_1' + \sigma_2' + \sigma_3') \,. \end{aligned} \quad (6)$$

During the history of the cracks the values of E_i at each time step must be checked up. If the old value of $E_3 < 0$ then the new value is $E_3 + \Delta E_3$. If the old value $E_3 > 0$ it means that the crack has been recovered and the new value is $E_3 = 0$. It can be seen that there is a potential source of errors, because of the early anisotropy is not taken into consideration. In fact, it is supposed that after the crack recovering the material tensile strength is the same. As the concrete tensile strength is not very high it is believed that this effect is not very important.

Equation of state. This part of the theoretical model uses the approach of Attala and Nowotny [5]. For the virgin concrete or for the partially failed concrete, the hydrostatic pressure is:

$$p = K(\Delta\varrho/\varrho - \sum_{i=1}^{3} E_i) \,. \quad (7)$$

Eq. (7) describes the concrete behaviour along the line KA in the fig. 5. Loading beyond the point A will cause failure due to crushing. Beyond this point the pressure follows the line AB, which has a smaller gradient than the line KA due to the porosity of the concrete. If the volume decreases beyond B the pressure is assumed to follow an elastic curve BC parallel to KA due to the concrete compaction.

Assuming a load release on the line AB, say at point D, the convectional plastic unloading takes place by leaving a permanent change of the volume. Thus, pressure falls along the line DE, then a void builds up while the pressure is stationary at zero. If the volume decreases the gap is closed immediately with the pressure at zero and the normal elastic curve GH is followed. The load release on the line KA and BC follows these lines.

Under the tensile loads, the negative pressure follows the line KA. At point K the concrete fails due to the tension. The pressure falls immediatelly to point L where the steel bars resist the loading alone. On further volumetric expansion the pressure first follows the elastic steel curve LM and after the elastic limit the line MP. The final failure is at point P.

If a decrease in the volume is signalized at point N, the tension will decrease either along the NN' or NT lines according to the material history. If concrete has previously failed due to the failure modes b) or c) the loading path will be the NN'. By decreasing the volume further the gap in the concrete will close with the resistance from the steel bars. When the steel is ruptured the equation of state for pure concrete can be applied.

3. IMPACT CALCULATION FOR REINFORCED CONCRETE WALL

The theoretical model presented in the chapter 2 has been included in the two-dimensional Lagrangian code CEFRA [1]. The code uses the finite-difference „midpoint" method and explicit time integration for solving problems of fast unsteady flow of elastic-plastic materials.

For the verification of the code the experiment of Goldstein et al. [6] was chosen. This experiment consisted of the cylindrical rigid missile impact (mass 50 kg, flat nose, impact velocity 112 m/sec) on the center of the reinforced concrete slab inserted in metallic frames, see fig. 6. The reinforcement was made of four layers of bars almost equidistant. Each layer was made of two crossed folds with a pitch of 8 cm with the bar diameter 1 cm and with the weight of reinforcement 260 kg/m³.

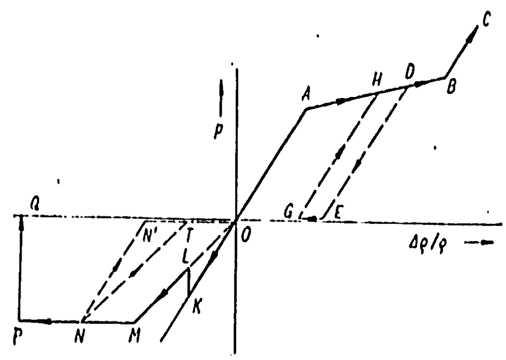

Fig. 5. The hydrostatic pressure of the concrete as a function of the relative density change

The CEFRA model for this experiment is in the fig. 7. A fully clamped boundary condition was chosen for outer radius of the disc. The main physical properties used for the calculation were following:

$\varrho_0 = 2.455 \times 10^6$ kg/m³ $\qquad \sigma_r = 54.1$ MPa
$K = 2.54 \times 10^5$ MPa $\qquad \sigma_{r,h} = 31.6$ MPa
$\mu = 1.84 \times 10^5$ MPa $\qquad k = 0.1$
$\lambda = 8.80 \times 10^4$ MPa

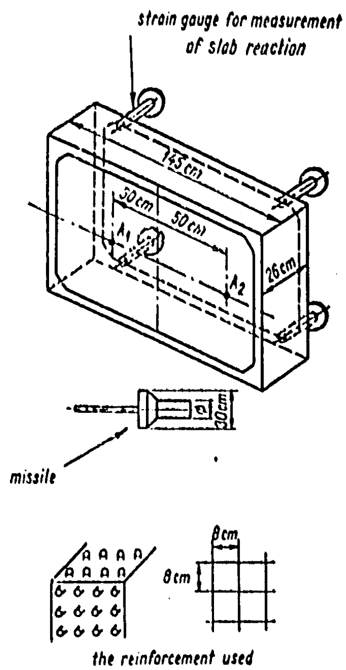

Fig. 6. The geometry of experiment [6] and the detail of the reinforcement

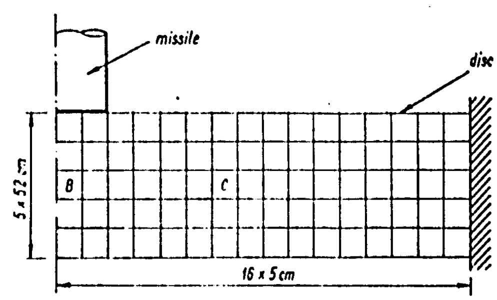

Fig. 7. The model used for the CEFRA code

The most important results of the experiment and of the calculation are shown in the fig. 8. There are the displacements of the impact area as the function of the time. The figure shows good agreement between the experiment and the calculation for the whole

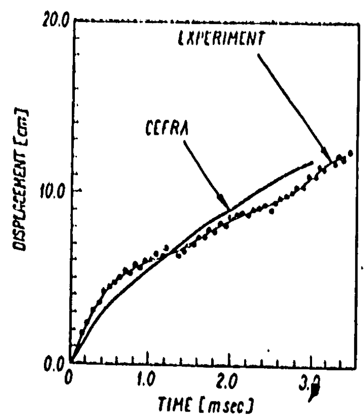

Fig. 8. The displacement of the disc center. The comparison between the experiment and the CEFRA code

interval of 3 msec. The greatest error which occurs at time 600 µsec is about 26 % but the general shape is similar and values are within the interval of error of aproximately 10 %. The great initial error may be caused by the fact that during the calculation the steel reinforcement is smeared in every zone without taking into account that the experimental slab had not the steel bars along the coordinate z. Also the shear stresses respect to the missile were ignored while the penetration is deep enough.

In the fig. 9 there are displayed the velocities for the wall in various times. The great deformation in the region near to the impact can be observed. The boundary region is practically without large displacement.

In the fig. 10 the propagation of the concrete failure modes is illustrated. The front face of the wall was destructed by compression and other part of the wall failed by cracking.

In the fig. 11 and 12 the shear stresses are displayed for the zones *B* and *C* respectively (see fig. 7 for identification).

In the zone *B* there is high positive shear stress (maximum 75.0 MPa) up to the time 900 µsec and after that it is practically zero. It is due to the very fast initial compression of the wall center while after that time the whole central part has the same displacement. The resistance to the impact must be after that time provided by the shear resistance of the outer part of the wall. This effect may be seen in the fig. 12. In the zone *C* the initial shear stress is a little negative due to the upper movement of the spalling region which is near to the zone. After about 900 µsec the shear stress becomes positive with maximum 3.2 MPa.

The time history of the shear stresses on the boundary is very important if the global behaviour of the complete structure (we can supposed that the disc is only isolated part of containment structure) is to be studied. We can calculate in this case the total force due to the shear stresses on the boundary and smooth its history in a way that impulse remains the same. The smoothed curve can be then used as an input for a dynamic analysis of the whole structure

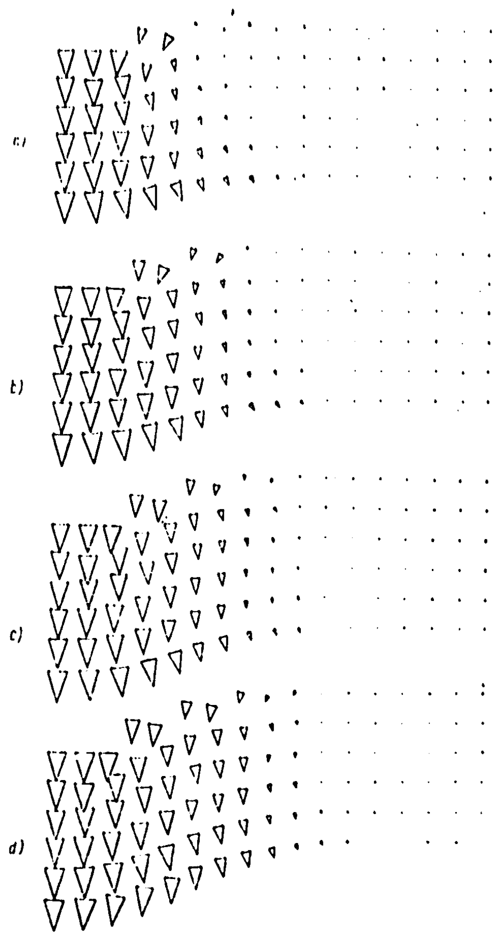

Fig. 9. The velocities display.
a) time 0.7 m sec, max. velocity 51.4 m/sec; b) time 1.4 msec, max. velocity 38.3 m/sec; c) time 2.1 msec, max. velocity 33.3 m/sec; d) time 2.8 msec, max. velocity 25.7 m/sec

with the scope to test the stability of the structure.

We believe that this approach is competent if the outer radius of the disc is chosen so that no significant displacement occur near to the boundary during the time interval of interest (we supposed implicitly also that the impacting time is short in comparison to the inverse of the fundamental eigenfrequency of the whole structure). Moreover, the safety factor 2 or greater can be used for the smoothed curve to obtain the driving force function for a dynamic analysis of the whole structure.

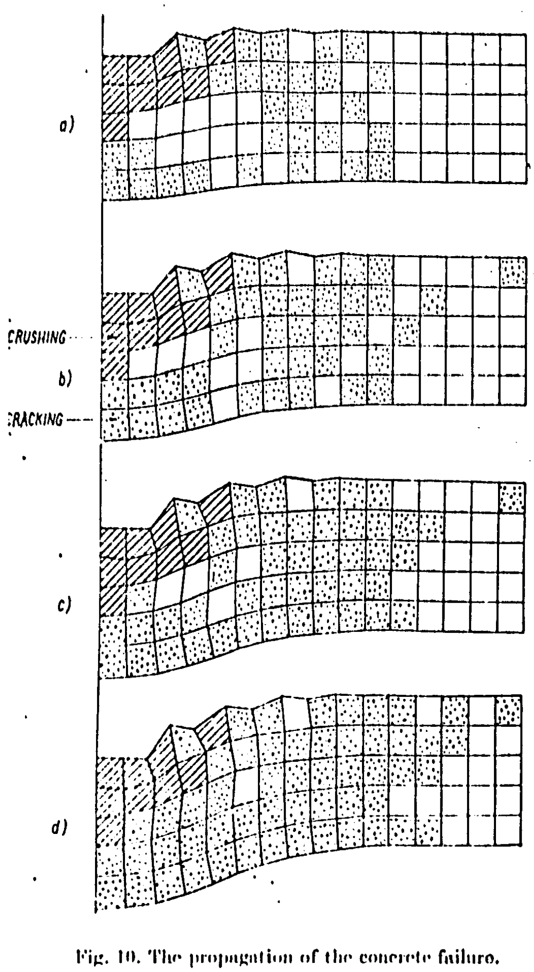

Fig. 10. The propagation of the concrete failure.
a) time 0.7 msec; b) time 1.1 msec; c) time 2.1 msec; d) time 2.8 msec

The code CEFRA automatically generates the force and impulse history on the boundary and the results for the studied case are in fig. 13 and 14. The results of the experiment are also included. The agreement between the measured boundary force and the calculated one is quite good. The calculated force oscillates along the experimental results but the time history of impulse is good.

The nature of the oscilations from fig. 13 is not only physical but also computational. It is clear that the strain gauges, see fig. 6, smoothed by their inertia the possible sharp peaks of the force during the experiment. On the other hand the solution by the CEFRA code in fig. 13 contains also artificial oscillations which resulted from the cracking failure scheme used. We supposed in chapter 2 that when the tensile stress exceeds a limit value the whole zone of interest sudden losts its strength. This assumption is a source of discontinuities. In the CEFRA code these discontinuities are damped by the use of artificial Navier-Stokes viscosity but the problem should be the object of the next research.

It must be noticed that experiment chosen is the case of impact with the great final penetration depth. The experimental penetration depth was 13 cm while according to the CEFRA code it is 16 cm (NDRC formula of USA gives 11,5 cm).

Better results can be achieved if we respect the anisotropy of the steel reinforcement and the shear stresses respect to the missile.

4. CONCLUSIONS

In the paper the theoretical model for reinforced concrete with cracks propagation has been described

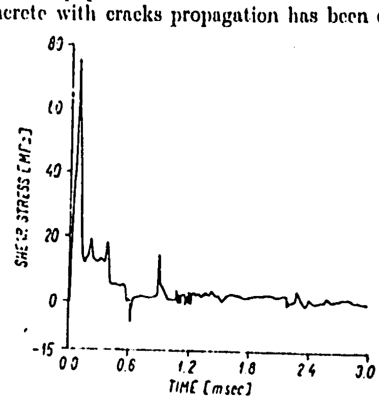

Fig. 11. The shear stress history in the zone B (see Fig. 7)

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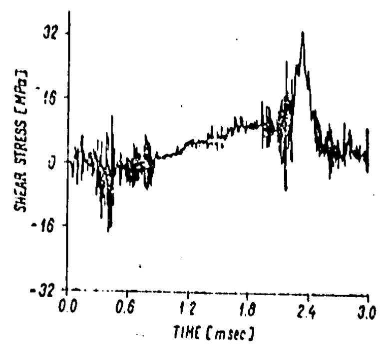

Fig. 12. The shear stress history in the zone C (see Fig. 7)

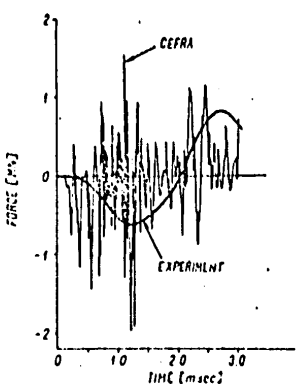

Fig. 13. The history of boundary force

and the results of the model for the experiment with the reinforced slab have been introduced.

It has been found that the code CEFRA is applicable to calculate realistically not only local missile effects but also the structural response of the target. The code can be used for great range of missile radius, mass, and velocity.

The code can be used in the future for the purpose of nuclear safety analysis in the fields:

— local impact phenomena due to the LOCA accident, turbine accident and various external impacts on the containment,

— aircraft crash and analysis of the containment response,

— response of the containment to combined extreme external events.

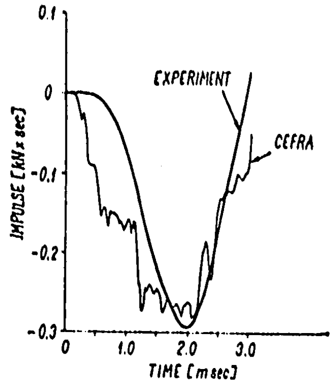

Fig. 14. The history of the impulse for the boundary force

NOMENCLATURE

Stresses and strains

$\sigma_1, \sigma_2, \sigma_3$ — principal stresses (tensile stress positive)

σ_c — uniaxial compressive cylinder strength ($\sigma_c > 0$)

σ_t — uniaxial tensile strength

σ_b — biaxial compressive strength

σ_0 — yield stress

$\varepsilon_1, \varepsilon_2, \varepsilon_3$ — principal strains (elongation positive)

$s_i = \sigma_i - 1/3J_1$ — principal stress deviators

$e_i = \varepsilon_i - 1/3I_1$ — principal strains deviators

Invariants

$$\left.\begin{aligned} J_1 &= \sigma_1 + \sigma_2 + \sigma_3 \\ J_2 &= 1/2(\sigma_1^2 + \sigma_2^2 + \sigma_3^2) \\ J_3 &= 1/3(\sigma_1^3 + \sigma_2^3 + \sigma_3^3) \end{aligned}\right\} \text{invariants of the stress tensor}$$

$$\left.\begin{aligned} S_2 &= 1/2(S_1^2 + S_2^2 + S_3^2) = \\ &= 1/6[(\sigma_1 - \sigma_2)^2 + \\ &+ (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2] \\ S_3 &= 1/3(S_1^3 + S_2^3 + S_3^3) = \\ &= J_3 - 2/3J_1J_2 + 2/27J_1^3 \end{aligned}\right\} \text{invariants of the stress deviator tensor}$$

$I_1 = \varepsilon_1 + \varepsilon_2 + \varepsilon_3$ invariant of the strain tensor

Material parameters

E — modulus of elasticity

ν — Poisson's ratio

$K = E/[3(1 - 2\nu)]$ — bulk modulus

μ, λ — Lamè constants

Miscellaneous

$\cos 3\Theta = 3\sqrt{3/2}\,.\,S_3/S_2^{3/2}$
$k = \sigma_t/\sigma_c$

$p = -1/3J_1$	— hydrostatic pressure
σ_{coh}	— cohesion stress
V	— specific volume
ϱ	— density
Δ	— increment
E_i; $i = 1, 2, 3$	— the measures of the cracks
σ_i'; $i = 1, 2, 3$	— modified principal stresses

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Adamík, V.

Teoretická studie železobetonových konstrukcí při rázovém zatížení vrženým předmětem

V článku je popsán teoretický přístup, který dovoluje předvídat poškození železobetonových stěn při osově symetrickém dopadu vrženého předmětu. Speciální podprogramy, definující chování betonu během rázu, byly včleněny do Lagrangeovského programu CEFRA a byly provedeny výpočty rázů pro tuhé vržené předměty. Výsledky ukazují, že teoretický model je věrohodný a umožňuje s přiměřenou přesností řešit i jiné podobné problémy extrémních zatížení kontejnmentu v celém intervalu žádaném programem bezpečnosti jaderných reaktorů.

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CZECHOSLOVAKIA

PRODUCERS OF AUTOMATED EQUIPMENT INTRODUCE PRODUCTS

Prague AUTOMATIZACE in Czech No 10 1978 pp 279-281

[Article by Ivan Dohnal: "Participation of VHJ [economic production unit] Equipment and Automation Plants [ZPA] at the 20th MSVB [International Engineering Trade Fair] Brno 1978"]

[Text] VHJ Equipment and Automation Plants today are already traditional participants in the Brno International Engineering Trade Fair. That they are also one of the successful participants is, among other things, evident also from the list of exhibits evaluated in the competition for the gold medal. Among the names of direct and indirect producers of awarded exhibits we find, almost every year, some of the organizations constituting VHJ Equipment and Automation Plants.

VHJ Equipment and Automation Plants participated in this year's 20th anniversary international engineering trade fair in Brno through their 22 enterprises and plants, which displayed 153 exhibits 44 of which represented new products.

The most extensive exhibition of products of VHJ Equipment and Automation Plants was in the second gallery of C Pavilion, where the direct exhibitor PZO [foreign trade enterprise] KOVO (trade group 7) displayed 56 exhibits from the area of measuring and regulatory equipment. The following were new products: linear motor ASM 5 (ZPA Novy Bor); immersible string thermometer Type 588, miniature string thermometer Type 590, adjustable string tensimeter Type 582, immersible string tensimeter Type 584 and Type 587, miniature string tensimeter Type 589 (ZPA Vinohrady); time switch H5 VS 1 D and speed controller IRO 130 (ZPA Dukla Presov); receiver FMX 15, memory relay RPK 50, time relay TX 11, frequency relay F 15 (ZPA Trutnov); pneumatic transmitter of pressure difference, pneumatic servomotor with a correcting network (from the GDR) and pneumatic lever servomotor (ZPA Jinonice); set of thermometers of the new series (ZPA Jinonice, Nova Paka plant); electric continous level reader and electric regulator TRS 123 (ZPA Jinonice, Usti nad Labem plant); electric servomotor KLIMACT KTI, electric servomotor MODACT, rotary electric servomotor MODACT MP III (ZPA Jinonice, Pecky plant).

PZO KOVO (trade group 3) displayed measuring instruments from national enterprise METRA Blansko and its plants in Brno and Sumperk. From a total of 40 exhibits the following were new products: accurate digital multimeter and laser measuring instrument LA 3002 (Metra Blansko); panel digital volt-meter MIT 240, portable digital multimeter MIT 242, safety equipment for mobile cranes P 043, contactless tachometer PU 420, transistor instrument for measuring ground resistance PU 430, and transistor contact thermometer PU 391 (Metra Blansko, Brno plant).

PZO Merkuria exhibited in the second gallery of C Pavilion time measuring devices and information equipment made by national enterprise Pragotron. Among the 12 exhibits displayed, the following were new products: electronic main clock HE 1 and a radio clock.

On the ground floor of D pavilion, PZO KOVO (trade group 4) displayed computer-controlled equipment in a total of 13 exhibits. The following were new products: input and output unit for elastic disks EC 5075 (Aritma); Digiplot 1208 and Digigraf 1712--3.5 G (ZPA Novy Bor); central digital unit for information and minicomputer control systems ADT 4410 (ZPA Trutnov); and a hybrid system ADT 7300 consisting of the analog section ADT 3000 and digital section ADT 4300 (ZPA Cakovice).

Laboratory Instruments national enterprise displayed 12 exhibits from the field of laboratory equipment in the exposition of PZO KOVO (trade group 6) in the first gallery of Z Pavilion. Among new products were the liquid chromatograph LCB, polarographic analyzer PA 2 with coordinate recording instrument XY 4103, vacuum meter PIRANI VPR 1, one-line recording instrument TZ 4100, rotary oil [air] pump RV 1.5/II, and rotary oil [air] pump LH S 1.5 A.

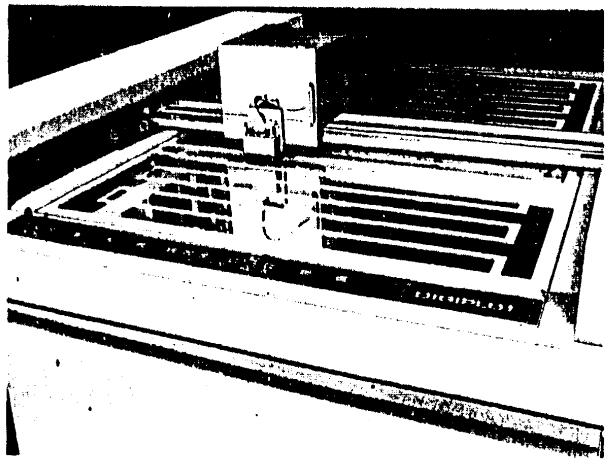
In other words, PZO KOVO displayed a total of 121 exhibits and PZO Merkuria 12 exhibits of products made by VHJ Equipment and Automation Plants.

In competition for the gold medal of the International Engineering Trade Fair Brno, VHJ Equipment and Automation Plants registered four top exhibits: drawing table Digiplot made by national enterprise Industrial Automation Plants Novy Bor; input and output unit for elastic disks EC 5075 produced by national enterprise Aritma; polarographic analyzer PA 2 made by Laboratory Instruments national enterprise and limited capacity level indicator SHL produced by national enterprise Industrial Automation Plants Jinonice, Usti nad Labem plant.

The above instruments and equipment have been described by their producers in this way:

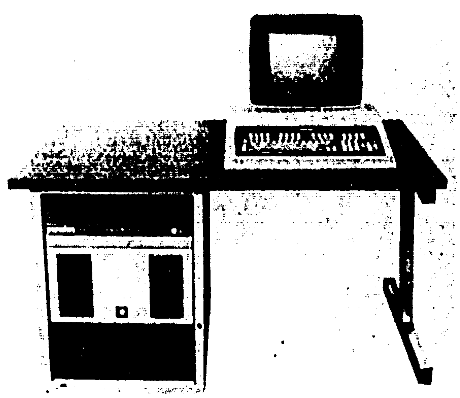
Digiplot

This is a drawing system with the maximum drawing speed of 250 mm per second and resolution of 0.01 mm on the 1,181 x 841 mm area (Fig 1). It draws



with the drawing ink or a ballpoint pen at full speed. Replacements of the point can be programmed and the drawing can be made with points of varying thickness, in various colors and on various materials. Digiplot consists of the drawing and control sections.

Electrostatic clamping of the paper is a standard feature of the drawing section. The control section (Fig 2) has a built-in Interdata 5/16 processor with a wide choice of peripheral equipment. Under the off-line



mode the basic model has in the input unit a reader for punched tape, but can be furnished also with a reader of magnetic tapes. The dual floppy disk is the basis of the operating process on the system and of input information. The system is controlled by the keyboard, which is part of the alphabetical digital display that is also part of the basic model. For the on-line mode the system can be equipped either with circuits for connecting it with the computer of the IBM 360/370 series or with an adaptor for synchronous of asynchronous data transmission permitting hook-up to any computer with appropriate software and hardware.

Static positional error tolerance is 0.08 mm.

The Digiplot drawing system is produced by national enterprise Industrial Automation Plants Novy Bor and was awarded the gold medal at the 20th International Engineering Trade Fair in Brno in 1978.

Input and Output Unit for Elastic Disks EC 5075

This is designed for direct data transmission from an elastic disk into the computer and vice versa. In analogy with card-punching equipment, it replaces the reader and key punch which are connected on-line with the processor.

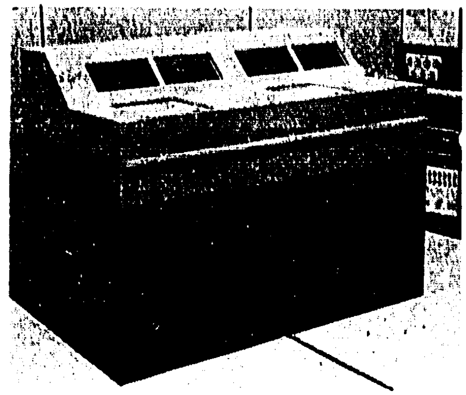
The unit consists of the recording medium on the elastic disk (EC 5074), elastic disk changer and control unit, including the buffer and port.

The elastic disk consists of the recording medium, which is permanently placed in a plastic sleeve. The surface of the recording medium is divided into 77 tracks, 73 of which are usually reserved for the user's data. Each track has 26 sections and each section contains one block of fixed length. A total of 128 bits is reserved for data in every block. The track capacity thus is 3,328 bits and the capacity of the entire disk 242,944 bits and corresponds to the contents of 1,900 punched cards. Input rate is 3,600 blocks and output rate 2,200 blocks per minute.

EC 5075 equipment can work only with the elastic disks initialized in advance, by which is meant that at least the section identifier must be recorded in advance in each section.

The automatic elastic disk changer permits replacement of a maximum of 20 disks without the operator's intervention. The cycle of inserting the elastic disk from the storage bin into the module and its replacement into the storage bin takes 5 minutes. The disks must be withdrawn from storage in the same order they were filed.

Two models of EC 5075 equipment will be available: as control unit with one elastic disk changer or as control unit with two independent elastic disk changers (Fig 3).



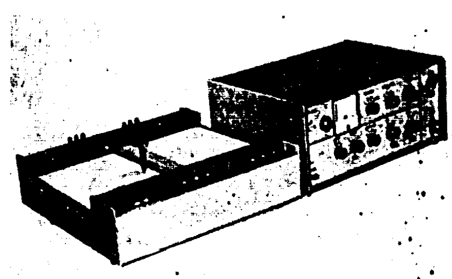
The built-in control processes instructions from the computer basic unit and on their basis controls the mechanism of one or two memories with the elastic disk changer and the data transmission between the computer memory and port. To the control unit belongs a sorter, one or two ports, one or two control panels, technician's panel and the power supply.

EC 5075 equipment has been designed as the component of the basis corresponding to the third and half generation of computers. It weighs 120 kg with one changer and 150 kg with two changers, and its dimensions are: length 1,160 mm, width 680 mm and height 940 mm.

The EC 5075 input and output unit with an elastic disk is manufactured by Aritma national enterprise.

Polarographic Analyzer PA 2 With Coordinate Recording Instrument X Y 4103

Polarographic analyzer PA 2 is an electronic instrument for polarographic work in research and analytical practice (Fig 4). It will be used in both



ferrous and nonferrous metallurgy, biology, pharmacy, medicine, and the food industry. It is suitable for the determination of depolarizers in up to 10^{-7} M concentration. If the method of dissolving volametry is employed, it may operate in up to 10^{-9} M or even 10^{-10} M concentration. It is equipped with the programming section which accelerates and facilitates the operation and considerably increases the accuracy and reliability of measurements. The instrument is designed for polarographic methods such as:

--conventional direct-current polarography with the two or three electrode system;

--sampling polarography;

--differential pulsating polarography;

--cyclical voltametry or

--differential pulsating dissolving voltametry with semi-automatic operation.

To the instrument belongs a flat coordinate recording instrument XY 4103 which permits recording of function y = f (x) and, after hooking up the time base to the input clamps of the coordinate x or y, also the recording of functions y = f (t) or x = f (t).

The coordinate recording instrument is primarily designed for work in combination with the polarographic analyzers, but is applied also in the analog and hybrid computer centers, research and development laboratories, development bases of production plants, centers for data processing and statistics, testing and measuring laboratories, and so on.

Polarographic analyzer PA 2 weight 12 kg and its dimensions are: 488 x 204 x 378 mm. Flat coordinate recording instrument XY 4103 weighs 10 kg and its dimensions are: 480 x 490 x 125 mm.

Polarographic analyzer PA 2 with the coordinate recording instrument XY 4103 is produced by national enterprise Laboratory Instruments.

Limited Capacity Level Indicator SHL

This instrument is used for measuring the minimum and maximum levels of loose, granular or liquid substances, electrically conductive or nonconductive, aggressive or nonaggressive which are placed in various types of storage bins: bunkers, silos, reservoirs and the like. The complete SHL set consists of a suspended or stick probe and evaluation equipment VZH.

The mechanical part of the probe consists of the electrode with an aluminum head and an electronic reader in the head of the electrode. The change in the capacity between the probe and storage bin wall caused by change in the level of material measured produces a change in the output direct current of the probe which is fed into the input clamps of evaluation equipment VZH. This signal is amplified in the integrated differential amplifier of evaluation equipment and carried to the flip-flop circuit. In the collector of the terminal transistor of the flip-flop circuit there is the coil of the relay which closes when the current from the probe equals zero. When the capacity changes because the electrode is surrounded by the medium measured, the relay is deactivated.

The suspended and stick probes can be placed in the spaces with the temperature of the environment surrounding the probe head ranging from minus 25 to plus 70 degrees Celsius, relative humidity from 30 to 80 percent, and working environment T2 according to CSN [Czechoslovak State Standard] 03 8805 and CSN 34 5681. Evaluation equipment VZH can be placed in similar spaces except that maximum temperature of the surrounding environment must not exceed plus 65 degrees Celsius.

Capacity indicator SHL consists of spark-resistant equipment. Completely sparkproof stick or suspended probes have been designed for the environment in which the danger of potential explosion corresponds to the hydrogen class of spark inflammability and to the second class of spark safety according to CSN 34 1499.

Evaluation equipment VZH with a sparkproof output for feeding the electronic part of the probe is placed in the environment where there is no danger of an explosion.

Stick probes weigh 1.8 kg and suspended probes 1 m long weigh approximately 7 kg. Evaluation equipment VZH weighs 2.5 kg.

Limited capacity level indicator SHL is produced by national enterprise Industrial Automation Plants Jinonice, Usti nad Labem plant.

[Captions]

Fig 1. Drawing section of Digiplot drawing system
Fig 2. Unit for operating Digiplot drawing system
Fig 3. Input and output unit with two independent elastic disks EC 5075
Fig 4. Polarographic analyzer PA 2 (right) and coordinate recording instrument XY 4103 (left)
Fig 5. Suspended probe of limited capacity level indicator
Fig 6. Stick probe of limited capacity level indicator
Fig 7. Evaluation equipment of limited capacity level indicator

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